Biophysical Experiments at the Vertical Beam Line ◇

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1. Introduction

The application of protons or heavy ions in radiotherapy is the main reason for radiobiological investigations using accelerator-ion beams [1,2]. The installation of the new vertical-beam facility for biophysical experiments was completed and first experiments started in the spring of 1997.

Beamtimes with different kinds of ions showed that all technical components worked as expected. The flux of particles can be adjusted over a wide range to the required dose-rates of various experiments. A uniform radiation field with a diameter of up to 60 mm can be prepared by active and passive beam spreading with a homogeneity better than 5 %. The irradiations are performed automatically under computer control.

2. Dosimetry

The dose determination is based on the counting of single particles by two-dimensional arrays of semiconductor and scintillator detectors with fast readout electronics [3]. The dose D is then calculated from the fluence F of particles and their stopping power dE/dx and the density ρ of the irradiated material.

$$D = \frac{F}{\rho} \cdot \frac{dE}{dx}$$

To verify our dose measurements we used a commercial ionisation chamber, which is in clinical use as a standard dosimeter. This parallel-plate chamber of Markus-type was developed for electron beams and can be used also for protons due to its thin entrance window. As integrating dosimeters Fricke solution and thermoluminiscence detectors (TLD) were used, additionally.

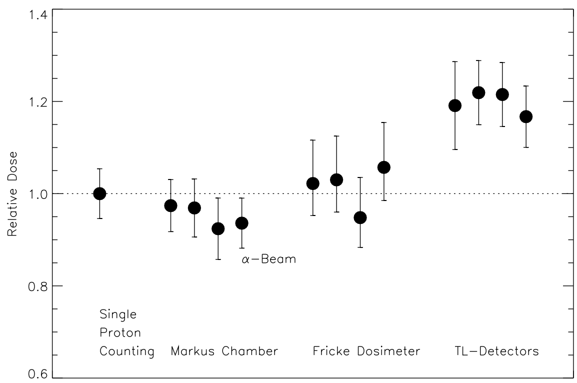

Fig. 1: Comparison of the results of different methods of dose measurements at different energies.

After irradiation of the $FeSO_4$-Fricke solution the amount of Fe^{3+} ions, which is proportional to the absorbed dose, is determined using a photometer. Thermoluminisence detectors made of LiF-crystals were irradiated. The emitted light during a specific annealing process is a measure of the absorbed dose. In fig. 1 the results of the different dose measurements are compared with our method of particle counting. All dose verifications suffer from the fact that the dosimeters are normally applied to photons or electrons and the results must be corrected for radiation fields of low energy particles. This may be the reason for the relatively high TLD-dose values. Therefore the TLD response to low energy particles shall be investigated in more detail in collaboration with the Health Physics Laboratory in Krakow.

3. Biological effectiveness of protons on mammalian cells

Biophysical experiments were initiated to study the survival of mammalian cells after irradiation. The cell samples are cultivated in the cell-culture laboratory in the nearby institute building, then irradiated at the vertical-beam irradiation facility and incubated for some days. The fraction of surviving cells is plotted in fig. 2. As is expected for relatively high beam energies and respectively low LET values (linear energy transfer) the curves show only a small deviation from the well known X-ray survival curve [4].

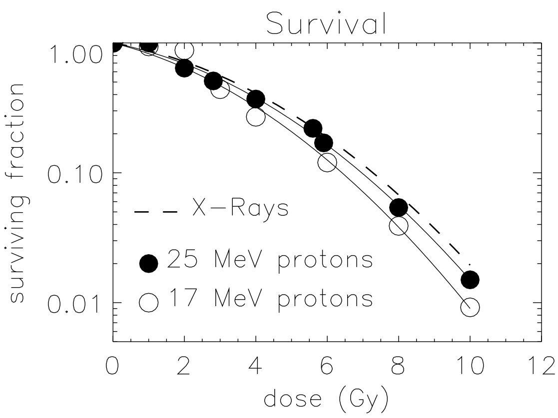

Fig. 2: Survival curves of B14 chinese hamster cells after irradiation

The experiments described aim at measuring the relative biological effectiveness (RBE) over a wide range of energies in a consistent way. Different, also human, cell lines at aerobic and anaerobic conditions shall be investigated. Test measurements investigating the apoptose of cells, chromosomic aberrations and DNA-damage are in progress.

References

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